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Proposed Cabin Safety Research Program (Transport Category Airplanes)

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Final Report

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16. Abstract

Cabin safety presents challenges common to all aviation authorities. Related issues and needed research must be accomplished through a totally integrated program.

To enhance their respective research capabilities, the U.S. Federal Aviation Administration (FAA) and the Transport Canada Aviation (TCA), the aviation authorities of North America, and the Joint Aviation Authorities (JAA), the aviation authority of Europe, have, as they have been doing in rulemaking, agreed to cooperate in research on transport category airplane cabin safety. The FAA/JAA/TCA Cabin Safety Research Program is the formalization of this agreement.

Specifically, the goal of the Cabin Safety Research Program is to provide a mechanism for the coordination of pertinent activities and, as appropriate, the conduct of cooperative, joint, and complementary programs to the benefit of the three authorities.

For the purpose of this program, cabin safety is intended to address acute events/conditions which can be dealt with by changes within (or closely associated with) the cabin. Although in-flight issues form an integral part of cabin safety, the primary focus is postcrash survivability, the principal elements of which are structural crashworthiness, fire safety, evacuation, and overwater survival.

The formost decision-making tools to identify and assess the potential benefits of needed research (and of past improvements) are a probabilistic risk analysis model and a cabin safety accident/incident information data bank/base.

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PREFACE

For many years the aviation authorities of North America, the U.S. Federal Aviation Administration (FAA) and Transport Canada Aviation (TCA) and in Europe, the Joint Aviation Authorities (JAA), have been conducting research in transport category airplane cabin safety, mostly individually and sometimes jointly and cooperatively, without the benefit of a coordinating tool. The international nature of civil aviation, current commitments and trends in harmonization, and budgetary constraints dictate the need for a mechanism to foster greater and broader association, cooperation, and coordination in cabin safety research. The Cabin Safety Research Program (CSRP) is intended to achieve this by bringing together the cabin safety research efforts of the FAA, JAA, and TCA.

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EXECUTIVE SUMMARY

Cabin safety presents challenges common to all aviation authorities. Related issues and needed research .must be accomplished through a totally integrated program.

To enhance their respective research capabilities, the U.S. Federal Aviation Administration (FAA) and the Transport Canada Aviation (TCA), the aviation authorities of North America, and the Joint Aviation Authorities (JAA), the aviation authority of Europe, have, as they have been doing in rulemaking, agreed to cooperate in research on transport category airplane cabin safety. The FAA/JAA/TCA Cabin Safety Research Program is the formalization of this agreement.

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1. OBJECTIVES.

1.1 PROGRAM.

The objective of the Cabin Safety Research Program is to enhance the effectiveness and timeliness of cabin safety research by establishing an international framework which allows for the systematic joint identification, prioritization and coordination of needed research, and integrates therein the pertinent activities of the FAA, JAA, and TCA.

1.2 PLAN.

The plan is the foundation of the program; it is the tool by which its objectives will be achieved. Broadly, the plan defines the program's parameters and implementation mechanisms and identifies the specifics of pertinent research activities.

Specifically, the plan:

- Defines the extent and scope of cabin safety and identifies its basic elements.
- Establishes mechanisms to assess the direction of current activities, identify needed future activities, establishes priorities with due consideration of the importance of the issues, available resources, and scheduling needs. In addition, the plan provides a continuing means of assessing the relative benefits of past, present, and future research activities.
- Provides means to identify, coordinate, and as applicable, integrate associated and related activities (both within and between authorities).
- Provides means to establish joint activities.
- Provides the basis to rationalize/justify both present and future research activities.
- Lists/details the activities/efforts, conducted both in-house and externally by contract, of the participating aviation authorities (both individually and jointly).

The plan is dynamic; it will be refined as work progresses and the tools are refined and will be amended as activities are completed and new ones are planned and/or initiated.

2. INTRODUCTION.

This overview defines the scope of cabin safety research, identifies those specific subjects for which research is planned, and identifies means for establishing research priorities.

In the context of this program, cabin safety is defined as protection against acute events, as opposed to chronic conditions (such as cabin air quality), within an aircraft cabin that can be addressed by a change within (or closely associated with) the cabin.

The various aspects of cabin safety include crash dynamics, fire safety, evacuation, ditching, in-flight medical emergencies and the effects in the cabin from turbulence and decompression. These subjects include in-flight as well as postcrash considerations and cover the spectrum of areas included in this plan.

All of these subjects will be addressed by the Cabin Safety Research Program Plan; although in some cases, the details of the work will have already been described in other specific program plans (e.g. the fire safety plan). In those cases, the relevant program will be referenced. For those items that are not currently covered by a specific plan, details will be provided in this plan. This plan will be used to collect and integrate the various research efforts underway in cabin safety, and maximize their benefit.

A key element in the program is the development of a comprehensive benefit and risk analysis. This will be based on data gathering and analysis, to arrive at a relative ranking of research activities in terms of expected benefit (versus cost), as well as to identify new areas of worthwhile research. In addition, a probabilistic risk analysis to assess the risks associated with various threats will be developed.

Cabin safety research needs to be conducted in a cooperative environment between aviation authorities, the JAA, TCA, and FAA in particular. The benefits of research, the cost of the research, and the resulting applications can all be enhanced by such cooperation.

3. SCOPE.

The primary focus of cabin safety is on postcrash survivability of occupants. Postcrash is intended in the broadest sense, including impact protection where evacuation is not critical, as well as evacuation-related events. Principal elements include crash dynamics, fire safety, evacuation, and ditching.

There are also several important, but less dominant objectives of cabin safety. These include in-flight incidents (turbulence, decompression, fire) and various safety items that fall into general design practice (e.g. no sharp edges or tripping hazards).

In general, this plan will focus on safety-related issues that can be classified as acute, occurring on a specific flight. Chronic matters, such as air quality or general product safety, that might otherwise be termed cabin safety are not addressed in this program/plan.

3.1 POSTCRASH SAFETY.

Postcrash safety consists of (1) protection from the crash itself, (2) egress from the airplane after the crash event, and (3) water/environmental survival.

Major areas relating to item (1) include occupant injury protection and human tolerance, adequacy of interior structural features (including seats, galleys, closets, and overhead stowage compartments), and ultimately airframe capability.

Item (2) can be further divided into (a) facilitating rapid egress and (b) extending the time available for egress. Included in (a) are exit performance, escape slide performance, interior arrangements etc., and many issues related to operational procedures. Included in (b) are improved flammability of materials, active fire suppression systems, burnthrough protection, protection of escape systems from the effects of fire, and enhanced ditching flotation time.

3.2 IN-FLIGHT SAFETY.

In-flight safety consists of the effects in the cabin from turbulence, decompression, fire, and medical emergencies.

Turbulence is primarily an occupant protection issue, although all occupiable areas of the cabin must be considered, not just those occupied for takeoff and landing. This relates to both design and procedures.

Protection against the effects of decompression involves oxygen systems and the capability of structures to tolerate pressure differentials without failures that could cause injury.

In-flight fire protection is primarily a function of design practice, flammability of materials, emergency equipment, and procedural considerations (e.g. no smoking in lavatories).

Medical emergencies relate to equipment standards and training procedures.

4. BACKGROUND.

Cabin safety has been the focus of extensive research in the past. This research has historically taken two primary forms: study of means to increase the speed at which evacuation from an airplane is possible and study of means to prolong the time available for evacuation. Examples of the former include exit sizes and access provisions, escape slide performance, and effects of interior features. Examples of the latter include material flammability and fire protection systems. In addition, research into human tolerance and impact protection has more recently assumed a greater overall role in research.

While each of these areas has its analog in other modes of transportation or public safety standards for housing large numbers of people, the airplane environment is unique in its constraints. The fragile economic posture of air transport dictates that some compromise in

absolute safety is necessary in order that commercial air travel remain viable as a mode of public transportation. The requirements for buildings, for example, do not have to address the weight associated with a fire protection system or the materials used in construction. Exit locations and sizes are not driven by the position of wings or the diameter of a fuselage. Emergency exits for buses can be installed without regard to the structural implications of maintaining a pressurized cabin. Thus, while standards used in other industries are useful guidelines, they are frequently inappropriate for incorporation in aviation requirements. For this reason, aircraft cabin safety has essentially no direct parallel and it is necessary to conduct dedicated research.

Until recently cabin safety research has been focused on specific issues and has been conducted mostly independently of other pertinent cabin safety research. Evacuation research at the FAA is conducted at the Civil Aeromedical Institute (CAMI) in Oklahoma City, Oklahoma; fire safety research is conducted at the Technical Center (TC) in Atlantic City International Airport, New Jersey. Research into crash dynamics is conducted at both facilities, with CAMI concentrating on human tolerance and seating systems and the TC concentrating on airframe structural performance. Research in Canada and Europe is conducted at various facilities.

In the late 1950s and in the 1960s, research tended to focus more on speed of evacuation than on extending the time available for evacuation. This was an outgrowth of several major accidents that occurred during that time in which the impacts were survivable, but there were still a high number of fatalities. This work resulted in several regulatory changes regarding access to exits, exit sizes, and escape slide performance. In the late 1960s and early in 1970s, a great deal of effort went into establishing suitable standards for widebody airplanes. This included development of the Type A exit and associated cabin interior considerations. For the most part, these standards went unchanged for the next decade, although research did continue in these areas.

Research activity in areas related to prolonging the time available for evacuation accelerated in the late 1970s and in the 1980s. This activity resulted in an unprecedented number of regulatory changes relating to material flammability and fire protection systems. Through extensive full-scale fire testing, the aviation authorities identified the principal fire loads in airplane cabins and the mechanism by which the environment became nonsurvivable. Test standards were then developed to discriminate between desirable and undesirable materials, and these standards were eventually incorporated into the regulations.

While a research program has been in existence since the 1950s, overall emphasis has only more recently been placed on impact protection and the associated human tolerance and aircraft structural performance parameters. This work involved an evaluation of the structural capability of the airframe using full-scale and small-scale tests, development of a test standard for occupants and a restraint system that would take that capability into account, and application of known human tolerance parameters (primarily derived from automotive standards) to develop appropriate pass/fail criteria.

While these research areas have been very productive and have resulted in improved safety standards, they have largely been carried out independently of one another. Up to now, there has

been no formal vehicle to integrate cabin safety research so that the benefits are maximized and the available funds are spent most efficiently. This plan serves as that vehicle.

5. BENEFIT AND RISK ANALYSIS.

The nucleus of the Cabin Safety Research Program is a comprehensive benefit and risk analysis based, in part, on past accidents and incidents. The study would collect and store, in a cabin safety library, all available information relating to cabin safety for past accidents and incidents. A model and starting point for the study will be the benefit analysis recently completed for cabin water spray (CAA Paper 93010). An attempt will be made to update past accident data by estimating and including safety improvements that have been incorporated since an accident (reference cabin water mist benefit analysis). The information gathered will be used to identify problem areas in cabin safety, determine the benefit (or disbenefit) of safety improvements (likely benefit from R&D), and determine the synergistic effects of a cabin safety improvement on overall cabin safety. In addition, the results of the study will be used as input into a probabilistic risk analysis. A risk analysis can provide more insight into potential safety benefits by attaching probability of occurrence to targeted events to balance the absolute safety benefit. This differs from traditional benefit analyses that merely extrapolate benefits based on previous accident rates.

This portion of the Cabin Safety Research Program will be ongoing with the continuous addition of new data (updating of the accident/incident data base). The intent is to use this approach to tie together cabin safety issues and assist in the setting of priorities by looking at the total cabin safety picture.

6. PROGRAM MANAGEMENT.

The program is managed at two levels:

a. Overall management is effected by the Steering Committe (SC) which provides general direction and guidance, establishes broad priorities, and addresses resources/funding and joint research issues. The SC consists of one (or more, as required) senior representative nominated by each the three participating organizations (FAA, JAA, and TCA), and meets annually (more often if activities or events so dictate).

b. Technical management of the research activities is performed by the Technical Group (TG), which is responsible for the identification, prioritizing, planning, coordination and general direction but not day to day managment of the various projects for the provision of regular briefings to the SC on the progress and findings of the various research efforts, and for all working aspects of the program. The TG members are also individually responsible for the provision of regular briefings and updates to their respective SC representative.

The TG is a core group consisting of up to 5 members from each the three participating organizations (FAA, JAA, and TCA) and representing both the research and regulatory elements of each organization (from the performing and customer groups). The TG meets regularly (approximately 3-5 times a year) and as needed to ensure the achievement of the program

objectives and the proper conduct and progress of the research efforts. As and when needed to address specific issues/activities, other authorities-related representatives (such as members of external research organizations or other government agencies) will be invited to participate in some of the TG's work.

In addition to the above, input relative to research needs and priorities will be sought, and received, from pertinent authorities-associated working groups and advisory committees such as the Aviation Rulemaking Advisory Committee (ARAC), the Research, Engineering and Development Advisory Committe (REDAC), the FAA/JAA/TCA International Cabin Safety Team (i*CST*), the JAA Cabin Safety Study Group (CSSG), and from recognized public- and industry-associated working groups.

7. RESEARCH ACTIVITIES.

The research activities that are ongoing or planned by one or more of the participating authorities and which forms part of this plan are listed below. Similar and/or parallel work by more than one authority are listed as separate projects. In the case of work presently being coordinated in a joint program, the activities have been combined and listed as one project. The benefit and risk assessment will tend to dictate the relative priority of these projects and to some extent, whether resources will actually be made available. Some projects are defined in other research programs/plans, which include: (1) FAA Aircraft Safety Research Plan (Nov 91), (2) FAA Fire Research Plan (Jan 93), (3) JAA Research Plan (1994), (4) FAA Aircraft Safety Research Plan (to be published in 1995), and (5) TCA Cabin Safety Research Program. Reference to these documents is made under the Performing Organization/Reference heading; if the research is not in one of these programs/plans, the mention None appears. The research activities are as follows.

7.1 BENEFIT/RISK DATA BASE AND ANALYSIS.

7.1.1 Cabin Safety Risk Analysis.

Objectives: Develop a risk analysis model and computer program to compute the risk to airline passengers arising from cabin accidents/incidents and the reduced risk and benefit assuming the implementation of various cabin safety improvements.

Background/Need: The Federal Aviation Act requires the FAA to develop regulations governing safety standards for aircraft. Aircraft safety includes improving occupant survivability when an accident occurs. At a meeting in December 1993 between the FAA Administrator and the Director of the CAA, it was agreed that the FAA and CAA would work together to address overall cabin safety. The nucleus of an integrated and harmonized cabin safety program is a risk analysis model. The JAA (representing the European aviation authorities, including CAA) and TCA have agreed to work with FAA on a joint cabin safety R&D program.

Description: The technical approach in developing the risk analysis computer program will be to utilize the following information: (1) state-of-the-art safety analysis technology, (2) historical data on accidents and incidents, (3) results of experiments and tests, (4) predictions of physical science models, and (5) expert opinions. Recent developments and improvements in risk analysis, such as in artificial intelligence in dealing with reasoning with uncertainty or vague knowledge, will be incorporated in the model. However, the user will control exactly what knowledge is used and what assumptions are made. Cabin safety issues to be addressed by the model include structural crashworthiness, occupant protection, passenger evacuation, fire safety, water survival, turbulence, decompression, and medical emergencies. The initial application and specific development of the model will be for a cabin water spray fire suppression system. Ultimately, the model will be applied to all of the aforementioned safety issues in order to compute the reduced probability of injury or death to passengers from the implementation of improvements. To support the model, an extensive data base of accidents, incidents, and historical data (trends) will be collected and computerized in a new library.

Performing Organization/Reference: FAA (TC)/None

7.1.2 Risk Analysis Data Acquisition/Development.

Objective: Develop/acquire specific data in support of the risk analysis model being developed by the FAA.

Background/Need: The FAA has initiated the development of a computer-based probabilistic risk analysis model intended to be a foremost tool to identify needed cabin safety research and to assess/quantify the impact of safety improvements. This model will be an essential decision-making tool of the Cabin Safety Research Program. The basic framework of this model has been developed, and extensive data must now be integrated therein to make it viable and useful.

Description: The following data will be acquired/developed (1987-1998 include):

- type/number of transport category aeroplanes in service (North America and Europe)
- for each aircraft type: passenger/flight crew/cabin crew capacity (minimum, maximum and average) and/or probability distribution
- for each aircraft type: number of departures (per day/week/month/year), departing and destination airport/country, and operator. (Data to be actual reported for 1987-1993 and estimated for 1993-1998.)
- Accident data for period 1987-1993: aircraft type, date and time, weather conditions, number of occupants (flight crew, cabin crew, and passengers) versus capacity, number and cause of injuries/fatalities, root cause of accident, departing and destination airport/country, operator, and state of registration.

Performing Organization/Reference: TCA/(5)

7.1.3 Database Analysis Techniques.

Objective: To further develop the CAA occurrence database.

Background/Need: CAA has identified new technologies that might enable its database to be analysed more effectively in the future. It will be necessary to expand the current system to integrate with other databases and to examine systems in other industries in order that a more effective system can be developed.

Description: A pilot project was completed in FY 94-95 and a system specification will be defined in FY 95-96.

Performing Organization/Reference: JAA (CAA)/None

7.1.4 Analysis of Survival Criteria.

Objectives: Analyze accident data in order to determine which factors or combination of factors affect the level of survivability of an accident and make proposals to tackle the problem of increasing survivability level.

Background/Need: Despite all precautionary measures, the continued growth of the traffic will result in an increase of the number of accidents. Actions have to be taken not only to reduce the probability of an accident but also to increase the passengers survivability. The level of survivability may vary a lot even for similar types of accidents. There is a need for the identification of the relevant factors or combination of factors in order to improve this level of survivability. DG VII (Transport) of the European Commission requested and funded a study on this subject. The results of this project will help to define the future orientations of the pre-normative research.

Description: January 95: The Cherry report identifies factors influencing the level of survivability of an accident. Delivery of an operating software for an accident database.

Performing Organization/Reference: DGAC-CHERRY and Associates Ltd/93/19

7.2 CRASH DYNAMICS.

7.2.1 General Requirements.

7.2.1.1 Occupant Crash Protection.

Objective: To define the scope of work required for a larger research project aimed at defining future requirements to improve occupant crash protection.

Background/Need: A major research program has been identified by CAA through the JAA Research Committee to examine how passenger aircraft can be designed to provide improved occupant survivability in a crash. This program is of particular interest to CAA because it would address a number of the AAIB's Kegworth safety recommendations. Such a program should address cabin floor integrity, stowage bin and cabin equipment integrity, improved occupant restraint devices, etc. JAA Research Committee has defined the outline of this project as part of an aviation safety research program.

Before such a program could be established, JAA Research Committee initiated a small study to define the objectives of the program, the scope of work required, and to establish if there is any work already completed or underway by other organizations. The single aim of this study was to produce a work statement for the larger research program.

Description: JAA Research Committee is seeking EC funding for the main program.

Performing Organization/Reference: JAA/(3)

7.2.1.2 Falcon 10 Crash Test.

Objectives: To validate with a test, the structure crash resistance computation model for small JAR/FAR 25 aircraft. To examine if the regulation relating to landing dynamic testing conditions is appropriate. To propose rulemaking changes and appropriate compliance demonstration means for business jet aircraft.

Background/Need: This study is included in FAA/DGAC cooperation agreement and in an extensive international research program (mostly American) leading to an improvement of various types of aircraft (large transport aircraft, general aviation) in case of an emergency landing. The study No 91/05 follows the study No 87/02. It is aiming at a comparison between numerical predictions and experiments. This comparison deals with the aircraft structural behaviour and the occupants survivability during a crash.

Description: A first report from CEAT was published. This report presents the analysis on the six instrumented dummies during the dynamic testing of the airframe, based on films and structural and dummies sensors.

Performing Organization/Reference: DGAC-DASSAULT-CEAT / 91/05

7.2.2 Seat and Seat Restraints.

7.2.2.1 Requirements for Side-Facing Seats.

Objective: To consider the human biomechanical load limits for side-facing seats with respect to the JAR 23/25 dynamic seat test requirements

Background/Need: Change 13 to JAR 25 introduced dynamic seat test requirements. For side-facing seats, problems arise with the application and interpretation of this new requirement, especially for the approval of the test setup and compliance criteria. For certification, it is necessary to have quantified the acceptable loads and the human biomechanical load limits.

Description: The study would carryout a literature investigation comparing the current requirements and advisory material for side-facing seats in aircraft with those for automobile crash tests and their associated test dummies. Human biomechanical load limits would be examined. Dynamic seat test would be carried out using current side-facing seats in addition and in coordination with work being conducted by DGAC/SFACT research to verify and record the biomechanical loads. The requirements and advisory material will be assessed during the project.

Performing Organization/Reference: JAA (BMV)/(3)

7.2.2.2 Occupant Restraint.

Objective: Within human tolerance limits. The improved analysis methods will include consideration of seat pan deformations and energy absorption characteristics of seat cushions.

Background/Need: Regulatory changes have been mandated for all new aircraft except commuter category airplanes. These changes require dynamic testing of aircraft seating systems as well as force levels to maintain these within human tolerance.

Description: None

Performing Organization/Reference: FAA (TC and CAMI)/(4)

7.2.2.3 Child Restraints in Aircraft.

Objective: Assess the performance of child restraint devices when used in aircraft seats.

Background/Need: Members of industry and the public have questioned the protection offered by child restraint devices used in aircraft situations. Aircraft seats feature important differences from automotive seats; yet the horizontal impact testing required for aircraft certification of a child seat uses an automotive type of test fixture.

Description: A representative selection of currently certified child restraint devices (CRDs) will be tested in aircraft seats using the crash pulse now required for newly certificated designs. The impact protection performance of these child restraints will be analyzed, and recommendations regarding inappropriate types of CRDs will be made. Potential revisions to testing standards for CRDs used in aviation will be suggested.

Performing Organization/Reference: FAA (CAMI)/None

7.2.2.4 Consolidation of Crashworthiness Information.

Objective: To create a single data source regarding performance and design of various restraint and crash protection system concepts. This information would be available both to FAA personnel evaluating compliance with regulations as well as industry personnel designing systems.

Background/Need: Consolidation of available information regarding performance and design of various seats and restraint systems would be valuable to the FAA and to seat and airframe manufacturers in complying with and evaluating compliance with FAA regulations.

Description: Information regarding the performance and design of aircraft seats and restraint systems will be collected into a single computerized public data resource available to FAA personnel and members of the public.

Performing Organization/Reference: FAA (CAMI) — Proposed/None

7.2.2.5 Aircraft Specific Child Restraint System.

Objective: To determine the feasibility of developing an Aircraft Child Safety System for use in commercial aircraft.

Background/Need: The lack of availability of purpose-designed child safety systems for use on aircraft has resulted in the general practice by Canadian airlines in the acceptance of usage of Canadian Motor Vehicle Safety Standards (CMVSS) approved automotive safety seats. A major problem is that all car safety seats do not fit in all aircraft passenger seats. Car safety seats are not configured to be fully compatible with the aircraft seat (e.g. break-forward seat backs—no attachment for the tether strap), nor are car seats fully tested with the aircraft seats in mind. With the future adoption of ISOFIX by the automotive industry, the compatibility problems will increase.

Until such time as the operational difficulties associated with the use of automotive devices on board aircraft can be shown to be resolved, the regulatory authorities are unable to mandate the use of child restraint systems at all times.

Description: Develop a child restraint system that meets the needs of the users, the regulators, and the airline industry. Those needs will be identified as mandatory or desirable requirements. The project will involve developing and testing a prototype child restraint device and subsequently determining the feasibility of transferring the knowledge gained into the development of a manufacturing prototype.

At the end of this project, recommendations for a standard for the development of aircraft specific child restraint systems will be made.

Performing Organization/Reference: TC and FAA (CAMI)/None

7.2.2.6 Side-Facing Seat Certification Procedure.

Objectives: Review of the side-facing seat certification procedure.

Background/Need: The interior furnishing of a business jet usually comprise of side-facing seats. The new JAR 25 change 13 refers to seat dynamic testing standards (amendment 64) which are not adapted to side-facing seats. This regulation affects for the first time the Falcon 2000 certification and problems with the compliance procedure are impairing the manufacturer in regards to a highly competitive environment. The objective of the SFACT was to finance studies in 1993 and 1994. These studies were cancelled. However, the subject is still on the JAA agenda.

Description: Definition of a JAA research program.

Performing Organization/Reference: DGAC/95/S/01

7.2.3 Cabin Furnishings.

7.2.3.1 Cabin Interior Integrity.

Objective: Develop methods for improving the integrity of cabin interior furnishings exposed to dynamic loads associated with crash impact accidents and the ability for occupants to egress the aircraft under impact conditions.

Background/Need: In impact survivable accidents, casualties can result from passengers being struck by furnishings breaking loose or by having egress paths blocked by these furnishings.

Description: Establish the necessity of dynamic testing of the requirements for increased margins of safety on static tests to meet dynamic requirements. Assess the adequacy of certification criteria for cabin interior furnishings by comparing dynamic loads with static certification requirements.

Performing Organization/Reference: FAA (TC and CAMI)/(4)

7.2.3.2 Overhead Bin Loading Survey.

Objective: To investigate overhead luggage bin loadings in operational use.

Background/Need: The House of Commons Transport Committee on Aircraft Cabin Safety included Recommendation IX which stated that: ‘We recommend that the maximum weight of baggage and clothing likely to be stowed in the overhead lockers be assessed by the CAA.” Chief Statistician UK CAA has reviewed methods of obtaining this information and a passenger survey will be undertaken in cooperation with Operators.

Description: Passenger survey on a representative number of routes.

Performing Organization/Reference: JAA (CAA)/(3)

7.2.3.3 Cabin Stowage Compartment Latch Integrity.

Objective: Review the types/designs of cabin stowage compartment latching systems on larger in-service aeroplanes to determine the likelyhood that they will remain closed during all phases of flight, specifically emergency landing/evacuation.

Background/Need: The airworthiness standards require that stowage compartments remain closed and retain their content (under applicable flight, ground, and emergency landing loads), with due consideration of wear and deterioration of latching mechanisms. There is evidence that, in some cases, compartment latching does not perform accordingly. This, in addition to creating a hazard to the occupants due to striking by items of mass, may cause an impediment to evacuation. The latter is of primary concern.

Description: The study will identify the types/designs of latching of the various stowage compartments (including overhead bins, dog houses, and supplies storage compartments) in the cabin of passenger-carrying transport category aeroplanes currently in service and evaluate such designs to ascertain the likelihood that they will remain closed in the case of an emergency landing/evacuation and accordingly retain their content and not become an impediment to evacuation. The study will include consideration of, amongst others, basic design/configuration, effect of in-service wear/deterioration, inappropriate/incomplete latch engagement, closure misalignment and compartment loading.

Performing Organization/Reference: TCA/(5)

7.2.3.4 Aircraft Interior Safety.

Objective: Determine the response of aircraft overhead stowage bins under dynamic test conditions.

Background/Need: Aircraft accident experience indicates that overhead stowage bin retention provisions may not be performing as designed or required. Specifically, the aircraft accidents which involved the B737 at Kegworth and the MD88 in Stockholm indicated this.

Description: The FAA Technical Center's Crashworthiness Program has been actively involved in research involving the dynamic testing of aircraft overhead stowage bins since 1991. A ten-foot-long narrow-body fuselage section, which had various overhead stowage bins installed, has been subjected to a series of longitudinal decellerations and one destructive vertical drop test to determine the reactions of the bins and attachments. The vertical drop test was intentionally structured to impose a dynamic load condition in excess of the current design and certification requirements so that the dynamic fracture loads and modes of fracture could be determined and evaluated. Technical reports have been published which document the test results.

Another narrow-body fuselage section is currently being prepared, with different overhead stowage bins, for another series of tests.

Performing Organization/Reference: FAA (TC)/(4)

7.2.4 Human Performance.

7.2.4.1 Impact Injuries to Lower Body.

Objective: Develop meansurement technology for the pelvis and legs of aircraft passengers and the ability to relate these measurements to injury risk (i.e., a crash dummy and injury criteria).

Background/Need: Revisions to the FARs in 1988 to increase the crashworthiness of aircraft seats have shown their value in some accidents, particularly the British Midlands crash at Kegworth, England in 1989. Analysis of this accident data has suggested that injuries to the pelvis and legs of passengers are a concern. These injuries are of particular concern because they may immobilize a passenger, preventing their escape from a postcrash fire.

Description: NHTSA's Biomechanics Division is launching an experimental program to collect information on human impact tolerance of the lower body. NHTSA's interest arises from automobile crashes where lower body injuries similar to those seen at Kegworth are found. NHTSA's program will develop injury tolerance relationships and analyze and develop Anthropomorphic Test Dummy technology to measure the relevant parameters. The British team which analyzed the Kegworth crash will be retained to provide analytical support needed to understand the postulated loading causing injuries in aircraft accidents.

Performing Organization/Reference: FAA (CAMI) and JAA (CAA) — Proposed/None

7.2.4.2 Improved Anthropomorphic Test Dummys (ATDs).

Objective: Evaluate the suitability and advantages of newer ATD technology and assess measurement needs that cannot be satisfied with current ATD designs.

Background/Need: The ATD currently specified in the FARs is an outdated ATD technology. Questions regarding limitations of this older technology, as well as questions of the suitability of newer ATD technology to aircraft situations have been raised.

Description: FAA crashworthiness regulations mandate the use of the Hybrid II ATDs, an outdated technology being replaced in automotive applications by the Hybrid III. The Hybrid III is itself a 20-year-old design, and questions regarding its applicability to aircraft have been raised. In addition, questions have been raised as to the proper ATD to use for evaluating side-facing aircraft seats and also questions in regards to child sized ATDs and the measurement capabilities. All of these issues will be examined. Where existing ATD technology is suitable for use in aircraft applications, this finding will be documented. Where appropriate for aircraft situations new ATD designs and measurement capabilities will be developed.

Performing Organization/Reference: FAA (CAMI)—Proposed/None

7.2.5 Analytical Modeling Development.

Objective: Enhance the capability of program KRASH to predict responses to different types of terrain and aircraft. Investigate various transport configurations including composite airframes and lower lobe settings.

Background/Need: The deficiencies in program KRASH needs to be identified, evaluated, and improved.

Description: High-fidelity modeling of the critical details of the seat/restraint/occupant is essential to the predictive capability of seat and occupant responses. The seat/restraint and occupant response models will be enhanced to provide more accurate response prediction. A SOMLA/SOMTA user seminar will be conducted to identify any problems or deficiencies in the programs. Analysis will include finite element modeling on advanced energy absorbing seat designs, seat cushion performance, infant seat/restraint systems, and Head Injury Criterion (HIC). Analysis will be validated with actual impact test data. User seminar on SOMLA/SOMTA will be conducted.

Performing Organization/Reference: FAA (TC)/(4)

7.3 EVACUATION.

7.3.1 Certification Testing.

7.3.1.1 Comparison of Aircraft Cabin Evacuations Using Slides Versus Platforms.

Objective: Compare and quantify differences in human behavior when evacuating from an aircraft using an evacuation slide versus a sill height platform.

Background/Need: In response to injuries to test subjects, proposals have been made to demonstrate compliance with FAR Part 25.803, and to perform research related to emergency aircraft evacuations. Differences in human performance between the two escape methods are not quantified or precisely known. This information is necessary to devise and evaluate tests and research.

Description: A sill height platform was constructed on one side of the Aircraft Cabin Evacuation Facility (ACEF) at the FAA's Civil Aeromedical Institute (CAMI) in Oklahoma City. An evacuation slide from a Boeing 737 was deployed on the other side of the fuselage. The ACEF was filled with human test subjects who were timed as they evacuated the aircraft as quickly as possible. Relevant anthropometric measurements (age, gender, weight, stature) were also collected. The size of the exit opening was varied between 3 different heights to study interrelationships between exit size and exit design (i.e., slides or platforms).

The research results of this study will provide a scientific basis for the evaluation of test plans submitted to show compliance with FAA evacuation regulations. The research will also provide a basis for the design of other evacuation experiments and provide needed parameter data sets for computerized evacuation modeling.

Performing Organization/Reference: FAA (CAMI)/None

7.3.1.2 Revisions and Improvements to the 90-Second Rule.

Objective: Devise an improved evacuation demonstration test for the current requirement in FAR Part 25.803.

Background/Need: The requirements of FAR Part 25.803 are controversial. The required test is expensive for manufacturers to run and represents a significant risk to test subjects. In addition, the test has been criticized as not representative of a true emergency and not providing a sufficient basis to determine that an aircraft possesses adequate consideration of emergency evacuation.

Description: Devise an improved and safer emergency evacuation systems performance test which may be adopted by the FAA for newly certificated aircraft.

Performing Organization/Reference: FAA (CAMI) — Proposed/None

7.3.1.3 Passenger Behaviour and Performance under Various Cabin and Exterior Lighting Conditions.

Objective: Acquire/develop basic data that will allow initial identification and assessment of the factors which influence the behaviour and performance of passengers evacuating onto slides, under various cabin and exterior lighting conditions.

Background/Need: Present standards require that a full-scale evacuation be conducted to demonstrate that transport category aeroplanes can be evacuated within 90 seconds, with passenger egressing onto slides, under low light conditions. Further due to the occurence of several injuries, the airworthiness authorities are considering alternate conditions for the conduct of this demonstration. One option is to perform the demonstration in normal lighting conditions. Basic initial data is accordingly required to assess same. (In addition, such data is needed to allow the further evolution and validation of the evacuation simulation models presently being developed.)

Description: The project will involve tests in which subjects will evacuate from a narrow-body (B-737) simulator onto slides under low and bright (normal) cabin and exterior lighting conditions, with cabin attendants exhibiting an assertive behaviour. Incentive payments will be used to motivate the passengers and simulate the appropriate evacuation urgency.

Performing Organization/Reference: TCA - (5)

7.3.2 Modeling.

7.3.2.1 Development of Computerized Evacuation Models.

Objective: Develop validated computerized models and parameter data sets of aircraft cabin evacuations.

Background/Need: The expense and risk to test subjects in running evacuation demonstrations and experiments creates a need for computerized evacuation models. These models will allow industry and the FAA to safely and inexpensively analyze issues related to emergency evacuation of an aircraft. These models will also serve as a valuable aid in analysis of survival factors in accident investigations.

Description: Currently, three separate computer evacuation models for aircraft exist. All models suffer from a lack of validated parameter data sets (and a model is only as good as the parameters that it uses), and there has been little validation of the models. In conjunction with other evacuation experiments in progress, data of use for these models will be collected and used to create parameter data sets. As parameter data needs are identified that cannot be derived from previously conducted experiments, new evacuation experiments will be devised and conducted to determine these values. The existing models will be evaluated with respect to their sensitivity to various parameters in order to identify those parameters with the greatest influence on a model's results. The use of simplified models (such as Markov analysis) will be compared to existing models to gain insight into when simplified models may be used. At the end of this project, a series of validation exercises will be conducted to assess the accuracy and applicability of models and data sets available at that time.

Performing Organization/Reference: FAA (CAMI)/None

7.3.2.2 Computer Modeling of Evacuations.

Objective: To provide the CAA with a computer based mathematical model capable of resolving questions relating to seating and emergency exit layout.

Background/Need: The CAA has identified areas of interest for the development of evacuation modeling:

- To quantify the effect on safety of having a defect on an aircraft, such as a non-serviceable door.
- To use as a tool to look at the relative effectiveness of different safety actions.
- To explore the implications of carrying non-ambulant passengers.
- To explore the feasibility of an alternative to the 90-second evacuation demonstration.
- To provide a tool for manufacturers to study the effect of cabin layout at the design stage.

Description: Professor Galea (CAA Professor of Mathematical Modeling at The University of Greenwich) has initiated the development of Exodus, this is potentially an extremely capable computer based model which incorporates the features necessary to model the complex interactions of a real emergency evacuation. This has been reported in CAA Paper 93006. A complementary program with the FAA involving evacuation trials at Cranfield and CAMI and modelling at Greenwich has been agreed upon. Presentations have been made to NTSB, AAIB, ISASI, and SCFSI and were well received.

The work will extract from the evacuation trials, previously performed by the Cranfield Applied Psychology Unit for the CAA, any additional data suitable for use by the modeling community and publish this data in a format that can be readily used. It will identify fundamental data that does not exist and arrange to obtain this data at any opportunity that may exist in the future. It will fund the development of a suitable PC based evacuation model. The merit of having more than one type of model to act as a cross check of any results will be considered. If satisfactory progress is made the model may be further developed to improve fidelity and to add features such as fire hazards.

Performing Organization/Reference: JAA (CAA)/(3)

7.3.2.3 Development of an Emergency Evacuation Simulation Model.

Objective: Develop a computer-based model capable of simulating the emergency evacuation of an aircraft.

Background/Need: The standards require that a full-scale evacuation be conducted to demonstrate the capability of an aircraft to be evacuated in emergency conditions. Such tests have resulted in a number of injuries and are extremely costly; moreover, they provide limited data on the evacuation qualities of an aircraft. A computer-based evacuation simulation model could address these problems and could provide a useful tool to assess the impact of various cabin configuration features to analyze accidents, to optimize the positioning of disabled passengers, and to assist in crew training.

Description: Aviation Research Corporation (ARC), on contract with TCA, is in the process of developing a powerful and extremely flexible PC computer-based evacuation simulation model (with a very sophisticated GUI) which, in addition to allowing modeling of the physical layout of a cabin, will integrate a wide range of occupant variables, including physical/physiological and behavioral characteristics. The model will offer the potential to perform three types of exercises: simulation of an evacuation (e.g. certification demonstration), assessment of the impact of various hazard scenarios on the evacuation of an aircraft, and reconstruction of a scenario (e.g. accident) given initial and end conditions.

The basic framework of the model has been developed and further work to pursue activation and enhancement of its features is scheduled. Longer term work is planned to acquire and integrate within the model the extensive full-scale test data needed to tune it and allow its validation.

Performing Organization/Reference: TCA/(5)

7.3.3 Human Performance.

7.3.3.1 Quantify Influence of Anthropometry on Evacuation Performance.

Objective: Quantify the influence of age, gender, weight, and height on evacuation performance so these considerations can be considered in matters of regulatory compliance and experimental design.

Background/Need: Preliminary data indicate that there are significant differences in evacuation performance due to anthropometric factors. While these considerations have been noted, there are no relationships quantifying these influences. Such information is needed when designing experiments, considering regulatory changes, and evaluating evacuation demonstration test plans.

Description: Anthropometric data on each experimental subject used in evacuation experiments will be collected and during the analysis portion of a study correlated with evacuation speed. In some cases, groups of experimental subjects differentiated by anthropometric variables (e.g. age) will be run in identical experiments and their evacuation performance compared and contrasted.

Performing Organization/Reference: FAA (CAMI)/None

7.3.3.2 Duty Station Location of Flight Attendants for Optimal Evacuation Through Type III Overwing Exits.

Objective: Determine optimal flight attendant location to minimize evacuation time when using Type III Overwing Exits.

Background/Need: Questions have been raised concerning operational requirements concerning flight attendant duty stations for evacuations from narrow-body aircraft using Type III Overwing Exits. This question is particularly important on certain aircraft which do not have exits rear of overwing exits. Depending on the passenger load carried, either a flight attendant be located at the rear of the aircraft, remote from an exit, or a third flight attendant may be stationed near the overwing exit. The influences of these different duty stations are unknown.

Description: A series of evacuation experiments using human subjects in a narrow-body aircraft cabin simulator will be conducted. All experimental subjects will evacuate through a Type III Overwing Exit. Current flight attendants will be stationed at the rear of the cabin, in the exit row, and in the row in front of the exit row. Experiments will be conducted in clear air and using a vision obscuring theatrical smoke. The time to evacuate will be recorded and differences due to the flight attendant location will be analyzed.

Performing Organization/Reference: FAA (CAMI)/None

7.3.3.3 Analysis of Competitive Behavior Experimental Protocols.

Objective: Provide an understanding of the affect of competitive behavior protocols in evacuation experiments and differences resulting from using different protocols.

Background/Need: In order to simulate panic among evacuating passengers, the Cranfield Institute developed an experimental protocol whereby test subjects are paid a financial incentive to be among the first to evacuate the cabin. CAMI used a similar system with significant operational differences to overcome perceived problems with the Cranfield protocol. Cranfield has also modified operational details of their experimental protocol. The affect of these differences has not been documented. If significant differences are discovered, analysis of the strengths and weaknesses of each system used is needed.

Description: Analysis will be conducted of previously run experiments at both Cranfield and CAMI where competitive behavior protocols were used. Differences and similarities between the affect of these protocols will be noted. The analysis will study not only differences between CAMI and Cranfield, but also variations in protocols within the same facility (e.g. Cranfield paid the first 50 percent out in some tests and the first 75 percent out in later tests). Where indicated, comparative experiments at both CAMI and Cranfield may be conducted.

Performing Organization/Reference: FAA (CAMI) and JAA (CAA)/None

7.3.3.4 Influence of Flight Attendant Behavior on Emergency Cabin Evacuation.

Objective: Determine the influences of the number, location, and behavior of flight attendants in emergency cabin evacuations.

Background/Need: Flight attendants have an important role in assuring the safe and speedy evacuation of an aircraft cabin during an emergency. Research on the number and duty stations of flight attendants is needed to determine the optimal evacuation of the aircraft. Activities and locations of flight attendants to minimize the affect of panic among evacuating passengers need to be determined.

Description: Evacuation experiments will be conducted using a Boeing 737 cabin simulator. Test subjects will exit through either one or two forward exits. There will be 2, 1, or no flight attendants present. In some test runs a financial bonus will be used to simulate panic among the evacuating test subjects. In other test runs cooperative behavior among the evacuating passengers will be featured. In some tests the seats will be reversed simulating passengers exiting through rear exits.

Performing Organization/Reference: FAA (TC and CAMI) and JAA (CAA)/None

7.3.3.5 Improvements to Passenger Education.

Objective: Determine improvements that can be made to increase passenger's knowledge of appropriate emergency activities.

Background/Need: Members of industry and the public have expressed skepticism that current preflight briefings by cabin crew adequately inform passengers of the information needed to survive an accident.

Description: A review will be conducted of safety briefings and the information retained by passengers and their ability to use the information.

Performing Organization/Reference: FAA (CAMI) — Proposed/None

7.3.3.6 Passenger Evacuation.

Objective: To reduce the time needed to evacuate passengers during a postcrash fire accident and to develop a methodology for the replacement of the 90-second full-scale evacuation certification test (with application to double-deck transport airplanes).

Background/Need: Past experience has shown that (1) delays in passenger evacuation during a postcrash fire can cause the loss of life, (2) some delays are avoidable with proper design and/or training, and (3) present certification testing, although useful, can be hazardous to the participants. Therefore, improved methods of detecting deficiencies and evaluating corrective actions must be developed.

Description: The technical approach will focus on the conduct of passenger evacuation trials in order to study passenger and flight attendant behavior and the influence of various aircraft configurations. In addition, a computer model will be developed and correlated with the evacuation tests. Once the computer model is validated, it will be used to limit the number and size of the passenger evacuation trials needed for certification of a new aircraft configuration. A new methodology will be developed for very large, double-decked transports that provide an alternate means of demonstrating compliance to the "90-second rule."

Performing Organization/Reference: FAA (TC and CAMI)/None

7.3.4 Equipment Evaluation.

7.3.4.1 Improved Evacuation Research Facility.

Objective: Develop a facility that will be fully responsive to future needs for aircraft cabin evacuation research.

Background/Need: Current facilities for conducting evacuation research are located outdoors, limiting the ability to conduct experiments in a controlled environment. Current facilities also rely on retired aircraft cabins, limiting the ability to respond to issues concerning newer aircraft designs, particularly wide-body cabins.

Description: A facility will be constructed in which evacuation experiments on either narrow- or wide-body aircraft can be conducted in a temperature and illumination controlled environment, with as many as 200 experimental subjects. A flexible cabin in which exits can be moved to any location, and single-, dual-, and triple-aisle cabins can be studied. The facility will also be able to study multi-deck aircraft cabins.

Performing Organization/Reference: FAA (CAMI) — Proposed/None

7.3.4.2 Emergency Evacuation from Wide-Body Aircraft Cabins.

Objective: Study and document differences in emergency cabin evacuations between narrow-body single-aisle aircraft cabins and wide-body dual-aisle aircraft cabins.

Background/Need: Dual-aisle wide-body aircraft cabins carrying hundreds of passengers present new and sometimes unknown considerations in emergency evacuation. In order to provide a scientific basis for regulatory decisions regarding these planes, an understanding of how their evacuation performance differs from narrow-body aircraft is needed. This issue will become more critical as concepts for new passenger aircraft carrying 700-1,000 people in multi-deck and triple-aisle aircraft are developed.

Description: CAMI is scheduled to obtain during FY-95 a retired Boeing 747 for use in evacuation research. This test facility will be used to conduct evacuation experiments that will be used to compare and contrast evacuation design considerations between narrow- and wide-body aircraft. This project will require the construction of a facility to house the evacuation test equipment and protect it from the weather.

Performing Organization/Reference: FAA (CAMI) —Proposed/None

7.3.4.3 Improved Evacuation Slides.

Objective: Determine improvements that can be made to aircraft evacuation slides to improve their safety and efficiency.

Background/Need: Analysis of injuries during evacuation demonstration tests and precautionary evacuations of aircraft in service has suggested that a many of the injuries result from design factors of the slides, such as illumination of the slide or performance differences between wet and dry slides.

Proposed new passenger aircraft will pose new questions related to slide usage when evacuating 700-1,000 people. Factors that influence people's perceptions of the safety of a slide and when to jump onto the slide are unknown, but affect slide efficiency.

Description: Design factors of evacuation slides will be evaluated. Required slide illumination levels will be studied, as well as the efficacy of slides needed for 700-1,000 passenger loads. The speed of passengers on a wet slide will be compared to that on a dry slide, and the safety implications for evacuations conducted in the rain will be analyzed. A review of the mechanisms of injuries to people using slides will be conducted and suggested design revisions considered. Factors that influence a person's perception of the risk of using a slide (e.g. angle with the ground, ability to see off to the side) will be studied. A new facility with a wide-body, multi-deck cabin in an enclosed, weather and illumination controlled environment is needed.

Performing Organization/Reference: FAA (CAMI) — Proposed/None

7.3.4.4 Ease of Operation of Type III Hatches.

Objective: To improve the effectiveness of Type III hatches, allowing the exit to be quickly available in an emergency.

Background/Need: In both the Manchester B737-200 and the Los Angeles B737-300 accidents, there were long delays in making the Type III exits available for evacuation. These delays have been attributed to the difficulties experienced by passengers when attempting to remove Type III hatches. CAA has funded some preliminary work (at Cranfield University) into the problems of operating Type III hatches. The results of this work and discussions with European authorities and AECMA have shown the need to expand these investigations into a comprehensive study of all the factors affecting Type III operation. This review covers four phases of testing and will be financed by the European industry, RLD, and the French DGAC. The testing undertaken at Cranfield represents Phase 1 of the above work.

In order to ensure consistency of testing approach, especially in the area of human factors, Cranfield will be funded to advise/assist with the European program. To complement the four-phase program, it is considered timely to carry out a design review of Type III hatches to establish if it would be feasible to engineer a hatch into the aircraft such that it would not be necessary for the person operating the hatch to physically lift and dispose of the hatch before the exit is made available.

Description: Review of possible methods of improving ease of use of Type III Exits, with particular emphasis on possibilities for retrofit of simple support mechanisms. A prototype mechanism will be constructed for evaluation within a cabin simulator. If a satisfactory mechanism is developed, then ease of use experiments will be undertaken to compare with the original removable hatch design.

Performing Organization/Reference: JAA (CAA)/(3)

7.3.4.5 Type III Exits.

Objective: To demonstrate the evacuation capacity of Type III exits.

Background/Need: The investigation was initiated by the JAA Cabin Safety Study Group and is the subject of DGAC and CAA cooperation.

Description: Contract has been under negotiations with Airbus Industrie to make an A320 fuselage section with Type III exits available for evacuation trials. Preparation of test facility and conducting an evacuation research program began in 1994.

Performing Organization/Reference: JAA (DGAC)/(3)

7.3.4.6 Effect of Abrupt Changes in Aisle Direction (Jogs) on Evacuation.

Objective: Acquire/develop basic data that will allow initial assessment of the effect on the evacuation process and time of abrupt changes (displacements) in aisle direction (often called jogs) in single-aisle transport category aeroplanes.

Background/Need: The cabin configuration of narrow-body aeroplanes typically comprises a single aisle with seats on each side of the aisle. The recent development of telescoping seats which can be readily reconfigured to different widths (to/from business/economy) is raising concerns relative to the effect of the resulting changes/displacements in aisle direction. Basic initial data is accordingly required. (In addition, such data are needed to allow the further evolution and validation of the emergency evacuation simulation models presently being developed.)

Description: The project will involve tests in which subjects will evacuate onto slides from a narrow-body (B-737) simulator equiped with 1-2 aisle jogs and cabin attendants exhibiting an assertive behaviour. Incentive payments will be used to motivate the passengers and simulate the appropriate evacuation urgency.

Performing Organization/Reference: TCA — (5)

7.3.4.7 Type III Emergency Exit Handling.

Objectives: To evaluate the impact of the handle design, the overlapping width of the panel and of the posted operating instructions on the time for handling and the evacuation process.

Background/Need: After the B737 Manchester accident and the approval by FAA of very stringent new rules of access to the type III Emergency issues (FAR 25-76 and 121-228), the JAA (Cabin Safety Study Group) have defined a joint research program aiming at the introduction of new European regulation. This program finalizes the already achieved studies on the influence of the width of the passageway and the ease of handling of the exit, through the analysis of several types of aircraft and emergency issues configurations, as well as the nonstudied widths. This study is part of the program.

Description: 19 Jul 93: Talks underway with Airbus for a contract.
31 Aug 95: Following talks between Airbus and STPA, the study was cancelled because of budgetary reasons.

Performing Organization/Reference: DGAC-AIRBUS/91/07

7.3.5 Additional Evacuation Research Needs.

Reactive Research: A particular cabin safety issue may suddenly become of great interest to the FAA with little advance notice or opportunity to prepare and a need to obtain data in short time frame. What these topics will be is unpredictable; however, the cabin safety research plan needs to recognize this need and plan for reactive research. The following are offered as potential reactive areas:

(a) Issues related to mobility impaired passengers. Given the current political climate and the requirements of some recent legislation, the impacts on evacuation performance of carrying mobility impaired passengers may become issues of concern to the FAA.

(b) Smoke hoods — an experimental program to quantify the delay in evacuation introduced by passengers using smoke hoods. The possibility also exists that some testing associated with certification of a passenger smoke hood may be required.

(c) Evacuation issues associated with other safety systems that might be developed.

7.4 WATER SURVIVAL.

7.4.1 Water Survival Factors in Aircraft Accidents.

Objective: Analyze differences between planned water ditchings and unplanned events where the aircraft stops in water

Background/Need: Current FAA regulations concerning water survival are based on a long overwater flight which develops trouble and performs a planned ditching at sea. This is a rare event, with only one accident of this sort in the past 30 years. However, many airports are located near rivers, lakes, and oceans. When accidents occur, in many cases the plane stops in water. Differences in training and equipment between these two situations needs to be studied.

Description: A review and analysis will be conducted of airline training programs and aircraft certification submissions concerning water survival. This review and analysis will also consider analysis of accidents over the past 30 years where water survival was a factor. Possible improvements to procedures and equipment will be suggested.

Performing Organization/Reference: FAA (CAMI) — Proposed/None

7.4.2 Review of Required Water Survival Equipment.

Objective: Update and modernize requirements for water survival gear carried on overwater flights.

Background/Need: Most of the requirements for water survival equipment carried on overwater flights are based on the state-of-the-art in World War II. Technological developments since then have made some requirements unnecessary and ignore important equipment readily available today but not developed in World War II.

Description: The need for long-term survival gear, such as fish hooks (currently required), is questionable today when survivors would be likely to be rescued within 24 hours. However, other equipment which can help immeasurably in locating survivors, such as a Global Positioning System, is not required. A review of all requirements for water survival equipment on aircraft will be conducted. A list of outdated unnecessary requirements and technological improvements that should be incorporated will be produced.

Performing Organization/Reference: FAA (CAMI) — Proposed/None

7.5 IN-FLIGHT ISSUES.

7.5.1 In-Flight Medical Emergencies.

Objective: Analyze the nature and extent of in-flight medical emergencies.

Background/Need: The FAA currently requires commercial airlines to carry a medical kit with prescribed equipment. The adequacy of this equipment and the question of whether there are personnel available with sufficient training to use the equipment is unknown.

Description: A survey will be conducted of currently flying airlines regarding their experience with in-flight medical emergencies. The survey will determine the types of medical emergencies encountered, and the adequacy of the medical equipment carried in the FAA mandated medical kits. Consideration will include an analysis of the training for cabin crew in handling medical emergencies. Anonymity of the carriers responding to the survey will be maintained.

Performing Organization/Reference: FAA (CAMI) — Proposed/None

7.5.2 In-Flight Turbulence.

Objective: Recommend improvements in design and cabin operations that will reduce injuries to passengers due to in-flight turbulence.

Background/Need: In-flight turbulence continues as a source of injuries (and occasionally deaths) in commercial aviation.

Description: A review will be conducted of injuries resulting from in-flight turbulence. This review will consider were injuries due to unrestrained passengers being thrown into cabin furnishings or were restrained passengers hit by loose items being thrown around the cabin. The nature and extent of injuries will also be considered.

Performing Organization/Reference: FAA (CAMI) — Proposed/None

7.6 FIRE SAFETY.

7.6.1 Systems.

7.6.1.1 Oxygen System Safety.

Objective: Develop guidelines or requirements for fire worthy oxygen system improvements to prevent catastrophic in-flight aircraft loss from fires that result from malfunction or oxygen involvement and limit aircraft oxygen system involvement in postcrash fires.

Background/Need: Recent service experience has demonstrated oxygen systems (solid gas generator as well as bottled oxygen) can malfunction with resultant 100 percent hull loss. Although the most recent events have occurred on the ground, each could have occurred in flight. In addition, aircraft oxygen systems have increased the fire hazard during some postcrash aircraft fires causing a reduction in survivable time, therefore causing an increase in fatalities.

Description: The technical approach will consist of studies to identify the hazards of in-use systems, full-scale tests of improved installations and the development of design guidelines.

Performing Organization/Reference: FAA (TC)/(1 and 4)

7.6.1.2 Onboard Cabin Water Spray.

Objective: Test, optimize, and develop an Onboard Cabin Water Spray System.

Background/Need: Postcrash fuel fires, when driven by wind through fuselage ruptures and door openings, can overwhelm regulatory improvements in cabin interior materials. Full-scale fire tests of prototype water spray systems have shown survivability improvements are attainable in many of these situations.

Description: Work will focus on the use of water spray for fire protection in areas other than the cabin. If successful, the cost of a cabin water spray system would be reduced.

Performing Organization/Reference: FAA (TC) and JAA (CAA)/(1,3 and 4)

7.6.1.3 Halon Replacement.

Objective: Determine if safe and effective substitute extinguishing agents can be used to replace halons 1211 and 1301 in aircraft. Develop certification criteria for approval of halon replacement agents and systems.

Background/Need: The Copenhagen Amendment to the Montreal Protocol on Substances that Deplete the Stratospheric Ozone resulted in the cessation of halon production on December 31, 1993. Halon is the extinguishing agent used in all commercial transport aircraft for engines, cargo compartments, lavatories, and hand-held extinguishers because of its combined fire fighting effectiveness and low toxicity.

Description: The technical approach will focus on full-scale extinguishment/suppression tests in four applications: cargo compartment, power plant/APU, lavatory trash receptacle, and handheld extinguisher to develop the equivalent effectiveness of candidate alternate agents for the currently used Halon 1301 and 1211. The International Halon Replacement Working Group will provide a forum for guiding test activities and exchanging information. Certification criteria will be developed for the agents/systems which are shown to be viable alternatives to Halon systems.

Performing Organization/Reference: FAA (TC) and JAA (CAA)/(1,3 and 4)

7.6.1.4 Cabin Water Spray.

Objectives: To identify the technical and economical problems which may result from the adoption of a water spray system against cabin fires.

Background/Need: Following accidents which involved a cabin fire, especially the Manchester disaster, several aeronautical authorities (CAA/FAA/DGAC/Transport Canada) initiated studies to assess the effectiveness of a water spray system aboard the aircraft. This system was intended to increase the survivability of the occupants during a cabin fire occuring on the ground. An extensive cooperation program provided an examination of the system's characteristics with the use of large scale demonstrations and also an evaluation of technical effectiveness and costs.

Description: The study is concluded. The system has a real effectiveness but needs optimization in order to be fully operational. The report was sent to the CAA and the CEE - DGVII.

Performing Organization/Reference: DGAC-AIRBUS/90/03

7.6.2 Materials.

7.6.2.1 Seat Components.

Objective: Develop an improved fire test method and evaluation criteria for application to cabin seat supporting structure and functional accessories (trays, passenger service units, etc.).

Background/Need: While recent regulations have upgraded fire safety for seat cushions and cabin lining materials, significant fire load can be found in seat accessories when formed of such plastics as polyvinyl-chloride, polyurethane, and polycarbonate. Additionally, new weight saving replacement of metal structures with advanced composites may further compound the flammability problem.

Performing Organization/Reference: FAA (TC)/(1 and 4)

7.6.2.2 Regulatory Support and Accident Investigation.

Objective: Support FAA regulatory offices in quick reaction tasks regarding present or proposed fire safety regulations. In addition support aircraft fire accident and incident investigations.

Background/Need: The Fire Safety Section contains expertise in the area of aircraft fire safety that is utilized by the FAA regulatory offices as well as other government agencies and the aviation industry as a whole for consultation, advise, and assistance on fire safety matters.

Description: The International Aircraft Material Fire Tests Working Group, comprised of aircraft fire test laboratories, will improve and simplify fire test methods as required. Engineers will participate in aircraft fire accident and incident investigations at the request of AAI-100. Fire tests and chemical analysis will be performed at the request of NTSB to support official accident/incident investigations. NTSB recommendations related to the permanency of seat fire blocking layers and the fire tests needs of airline blankets will be addressed and the technical basis for FAA response will be developed. Used fire blocking layers received from industry will be tested to determine the degree of fire resistance degradation. A test standard for blankets will also be developed (some blanket types will burn uncontrollably when lighted with a match in spite of the use of fire retardant treatments). Finally, tests will be conducted in a Shorts 330 airplane to develop improved fire safety design criteria for accessible cargo compartments in commuter aircraft. Previous tests showed that current fire fighting practices are inadequate.

Performing Organization/Reference: FAA (TC)/(1 and 4)

7.6.2.3 Fuselage Structural Fire Safety (Burnthrough).

Objective: To evaluate techniques and materials which may offer further protection for cabin occupants against the effects of external ground fires and to help define any future JAA requirements.

Background/Need: The AIB report on the Manchester accident severely criticized the lack of FAA fire safety design criteria related to fuselage burnthrough resistance (Aircraft Accident Report 8/88). Recommendation 4.20 from this report speaks to 'increased effort directed towards fire hardening of the hull, the limitation of fire transmission through the structure, and the prevention of structural collapse in critical areas." AIB estimated that the fire penetrated the cabin within one minute of the aircraft stopping and that the inadequate burnthrough resistance was a major causal factor in the fifty-five fire fatalities. Analysis of aircraft crash fires indicate that the fuselage is intact in approximately 50 percent of the accidents; whereupon, burnthrough may be the most important mechanism for ignition of the cabin interior.

The CAA has commissioned the construction and validation of a reproducible heat source facility to evaluate the fire resistance of various fuselage subassemblies (skins, floors, windows, hatches etc.). This facility has been characterised for a heat output and test sample position appropriate for the testing of fuselage skin subassemblies. This facility has been used to investigate the relative importance of features of conventional aircraft construction such as rivet lines, skin joints, thermo/acoustic insulation, etc. Results will be correlated with full-scale testing to be undertaken by the FAA.

All commercial transports in operation today employ aluminum alloys in the construction of the fuselage skin. In order for the HSCT to be viable, the fuselage skin will be composed of composite material. Since aluminum is noncombustible within the content of a postcrash fuel fire it does not present a fire safety issue. However, composites are composed by organic materials which will burn to some degree when exposed to a fuel fire; of concern is whether a composite skin airplane creates greater hazards during a postcrash fire as compared to an airplane constructed with aluminum skin. Specifically, will the pyrolysis products from the composite skin create hazardous levels of smoke, toxic gases, and combustible gases within the cabin. Full-scale fire tests have never been conducted on aircraft fuselages employing composite skins. This type of data are required before a composite skin airplane could be certificated.

Description: The technical approach will consist of full-scale fire tests to determine the path and time of framework for burnthrough and to demonstrate the effectiveness of proposed design improvements. A small-scale fire test will be developed to screen improved materials and design concepts. Similar testing, evaluation, and development will be undertaken on composite fuselage skin being developed for the HSCT in addition to burnthrough resistance; a major concern is the hazards from pyrolysis of the composite skin (smoke, toxic gases, and combustible gases).

Performing Organization/Reference: FAA (TC) and JAA (CAA)/(1,3 and 4)

7.6.2.4 Very Large Commercial Transport Fire Safety.

Objective: Develop fire safety design requirements or guidelines for future double-decked transports carrying 500-800 passengers such as the Very Large Commercial Transport (VLCT).

Background/Need: A double-decked passenger transport is a revolutionary design. The problem, of course, is that there has never been an analysis or full-scale tests related to the vulnerability of the upper cabin to a postcrash fire. However, there is compelling evidence that fire will spread and grow faster in the upper cabin. FAA full-scale burnthrough tests on a contemporary aircraft demonstrated that there is significant fire growth in the passenger cabin before any indication of fire in the lower cargo compartment. Also, accidental fires in B-747s have shown very extensive fire damage in the upper cabin.

Description: The technical approach will primarily consist of full-scale fire tests to characterize the postcrash fire environment in a double-decked transport and to develop and evaluate design improvements which are expected to be shown warranted. Of concern is the vulnerability of the upper deck to more rapid spread of fire and accumulation of hazardous conditions because of the natural tendency (buoyancy) of fire to spread in an upward direction. Expected difficulties in evacuating a very large number of passengers adds to the vulnerability of the upper deck. A double-decked test article will be constructed and postcrash fire tests will be conducted in the Full-Scale Fire Test Facility. The initial characterization tests will serve to isolate and define the problem areas. This will be followed by testing and evaluation of design improvements, also under full-scale conditions. It is envisioned that fire stops, designed to inhibit the spread of fire into the upper deck, will be examined thoroughly.

Enhancement of passenger survivability in the upper cabin by water spray and improved fire resistant materials will be evaluated and compared on the basis of effectiveness and cost. Needed improvement in the strength of floor beams exposed to fire, particularly for the upper deck, will be examined. The final product will be fire safety design recommendations required to maintain the level of safety in double-decked transports as currently exists in today's airliners.

Performing Organization/Reference: FAA (TC) — Proposed/None

7.6.2.5 Evaluation Of Materials' Fire Resistance (FAR 25 amdt 61).

Objectives: Fire resistance covers the following area:

- evaluation of the fire resistance of materials used in the cabin
- study of burnthrough
- possibilities for a large-scale fire test

Background/Need: Passive safety including fire resistance has evolved steadily during the past ten years. This was the reason for different amendments to the FAR and JAR (refer to FAR 25-61, and 66). With reference to this background, it was considered essential to study the fire resistance of materials used in the cabin as well as the required approach for ensuring safety especially during postcrash fires.

Description: Materials behavior regarding cabin fires was examined and the variety in materials characteristics was pointed out. Although it has been sometimes stated, the correlation between smoke and heat release was not proved.

In addition, it was found out that the realization of a large-scale fire test was very complex.

Performing Organization/Reference: DGAC-AEROSPATIALE / 88/06

7.6.3 Mathematical Modeling of Aircraft Fires.

Objective: To provide regulatory authorities with a means of assessing the susceptibility of aircraft cabin configurations to fire, without recourse to full-scale fire tests.

Background/Need: Because of the inherent difficulties and expense of conducting full-scale fire tests on aircraft, the CAA has for a number of years been funding, at low level, the development of transputer systems and software to enable the Mathematical Modeling of aircraft cabin fires using computational fluid dynamics techniques. With the advent of low cost fast processing devices, these techniques are becoming more viable. In the past this project has had considerable financial support from SERC; however, this funding has not been available for the current year. British Aerospace was taken over the funding commitment and have contracted to support The University of Greenwich in this work for three years. CAA has entered into an agreement with both Greenwich University and British Aerospace to remain involved with the work and to provide limited funding. This work is planned as a three-year project.

Description: The capability has now advanced to a point where, following the development and correlation of simple fire models, a high-fidelity model of the Manchester B-737 fire has been produced in order to study the mechanisms involved in the rapid propagation of the fire in this accident. Professor Galea has presented papers at the 18th International Fire Safety Conference on behalf of the CAA. To continue the development of appropriate aircraft cabin fire models running on transputer based systems and develop the software into a system that can be more readily used as a research or investigative tool. The results from the Manchester fire simulation will be reported and a Video depicting the graphical output from the computer will be produced. The project is entering the third year of the three year agreement involving BAe.

Performing Organization/Reference: JAA (CAA)/(3)

7.7 LONG-RANGE FIRE RESEARCH.

Objective: To eliminate fire as a cause of fatalities in aircraft accidents.

Background/Need: Achieving the FAA's fire research goal requires advances in both fire science and the use of new electronic, chemical, and material technologies for aircraft fire safety improvements.

Description:

a. Fire Modeling. Development of a computer model to predict fire growth and propagation patterns.

b. Vulnerability Analysis. A long-term program to develop predictive means of assessing various fire safety matters.

c. Fire Resistant Materials. Work towards the goal of a fireproof cabin interior.

d. Improved Systems. Reduce or eliminate the fire hazard from present aircraft systems.

e. Advanced Suppression. Work in the area of the next generation agents/systems.

Performing Organization/Reference: FAA (TC)/(2)

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